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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 63.

THE WORK OF THE AGRICULTURAL EXPERIMENT STATIONS ON TOBACCO.

Abstracted by J. I. SCHULTE, Office of Experiment Stations,

WITH INTRODUCTION AND COMMENTS BY

MILTON WHITNEY,

CHIEF, DIVISION OF SOILS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

RECENT PUBLICATIONS OF THE DEPARTMENT ON TOBACC

Bulletin No. 11, Division of Soils.—Tobacco Soils of the United States, a Preli inary Report upon the Soils of the Principal Tobacco Districts, by Milton Whitney Chief of Division of Soils.

Farmers' Bulletin No. 60.—Methods of Curing Tobacco (revised edition), by Milt Whitney, Chief of Division of Soils.

Farmers' Bulletin No. 82.—The Culture of Tobacco, by Otto Carl Butterweck.

Farmers' Bulletin No. 83.—Tobacco Soils, by Milton Whitney, Chief of Divisic of Soils.

Cultivation of Tobacco in Sumatra, by Emile Mulder.

Report No. 59.—Curing and Fermentation of Cigar-leaf Tobacco, by Dr. Osca Loew, of the Division of Vegetable Physiology and Pathology.

Report No. 60.—Temperature Changes in Fermenting Piles of Cigar-leaf Tobacc by Milton Whitney and Thomas H. Means, of the Division of Soils.

Report No. 62.—Cultivation of Cigar-leaf Tobacco in Florida, by Marcus L. Floyd of the Division of Soils, in cooperation with the Division of Vegetable Physiolog and Pathology.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Soils,
Washington, D. C., January 6, 1900.

Sir: In taking up the line of tobacco investigation, authorized by the Fifty-fifth Congress, it was considered desirable to review the work done by the experiment stations. To this end Dr. A. C. True, Director of the Office of Experiment Stations, was requested to have an abstract made of all such work and he detailed Mr. J. I. Schulte of that office to compile this data.

As I believe the results of the experiment station work thus brought together will be of value to the stations in planning further, more systematic, and more comprehensive work, and as they will also be of interest to tobacco men, I recommend that the accompanying manuscript be published as Report No. 63 of this Department.

Respectfully,

Milton Whitney,
Chief of Division,
In charge of Tobacco Investigation.

Hon. James Wilson,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., January 2, 1900.

Sir: In accordance with your request I send you herewith abstracts of the accounts of investigations on tobacco, which have been published by the agricultural experiment stations in the United States and Canada. These abstracts have been prepared by Mr. J. I. Schulte, of this Office, in accordance with my instructions. Only in a few States have the experiment stations undertaken tobacco investigations in any thorough manner. In many cases their studies on this subject have been incidental to other inquiries or have been distinctly minor pieces of work. This will very largely account for the fragmentary character of the work, as indicated in this summary.

Respectfully,

A. C. True,
Director.

Prof. Milton Whitney,
Chief of Division of Soils.

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THE WORK OF THE AGRICULTURAL EXPERIMENT STATIONS ON TOBACCO.

INTRODUCTION.

For some years past the agricultural experiment stations in various sections of the country have carried on investigations in the raising and curing of tobacco. This work for the most part has been desultory and, being published in so many bulletins—often as a small note or record of progress—it was considered advisable to bring the work together in order to show what lines had received attention and what results had been attained. It is hoped that by thus bringing together the lines of work and presenting the subject as a whole, some of the stations may be induced to take up the subject in a more comprehensive and thorough manner and throw more light upon the various phases of the growth and curing of tobacco which have assumed such a degree of economic importance in many districts of this country.

Some of the subjects which have been investigated by the stations have been fully worked out by growers in one or more sections of the country, and there are a number of problems which the growers have solved by themselves without the intervention or assistance of the stations. Then again there are many problems now confronting the tobacco growers which they have not been able to solve and which the experiment stations have not taken up, or at least have not published reports upon. So far as possible in the limits of this article, these subjects are briefly referred to, in order to make this report as full, comprehensive, and valuable as possible.

Tobacco, as a commercial crop, is at present confined to a very few of the States, and to limited and rather well-defined areas in those States. It thus happens that only a very few of the agricultural experiment stations are located in or near tobacco districts. The tobacco industry has become so highly specialized that it is necessary for the successful investigator to become closely identified with the economic details of tobacco culture and handling in order to both intelligently select material to work with and to plan the work for some real economic advancement. Under these conditions it would never be desirable for many stations to undertake investigations in

tobacco, but it would be very much better if the work could be centralized and undertaken in a systematic way by two or three stations favorably located for this work. It is well to realize this fact, as there is no question that the difficulties in the way of investigations along valuable economic lines are so very great and require so much technical skill in the manipulation of the leaf that it is considered very far from advisable for stations to undertake the work unless they are well equipped and favorably located.

Much of the work which has been done is of marked value. As will be seen from the table of contents, it has covered a great range of subjects. Nevertheless, it would be better for the stations to concentrate the work rather than for a great number of stations to undertake these particular lines.

METHODS OF GROWING PLANTS IN SEED BEDS.

Various methods of starting tobacco seed were compared at the Alabama State Station in 1892 and 1893.[1] Seed was started in open beds and in beds covered with cheese cloth. During the first year of the experiments the greater number of plants in the open beds were destroyed during a cold spell in March, and during the second season they were injured by the flea beetle. In the covered beds the plants came up well, grew rapidly, and were not subject to insect attacks. From the results obtained it is evident that under the climatic conditions of Alabama young tobacco plants are readily affected by low temperatures and quickly killed by freezing weather. The method of starting the seed in a covered bed was the most successful.

The Colorado Station[2] in pursuing this work in 1889 found that it took no longer to produce plants suitable for setting out by growing seeds in cold frames than by the use of the hotbed.

The following method of germinating tobacco seed proved perfectly successful at the Georgia Station in 1892.[3] Tobacco seed was placed in wine glasses and soaked in water for half an hour. The water was then poured off from the seed and the glasses placed in saucers containing water, and a tumbler inverted over each glass to confine the moistened seed in a damp atmosphere. The glasses were then placed in a warm room and the seed kept moist. About a week afterwards, when the seed began to sprout, it was sowed in a cold frame, and within four weeks from that time plants suitable for transplanting to the field were obtained.

Experiments in growing seedling plants were conducted at the Central Experimental Farm, Canada, in 1893 and 1897.[4] Seed was sown

[1] Alabama State Station Buls. Nos. 44 and 54.

[2] Colorada Station Bul. No. 10.

[3] Georgia Station Bul. No. 19.

[4] Canada Expt. Farm Rpts., 1893 and 1897.

in hotbeds, and some of the plants produced were transplanted to cold frames and hotbeds before they were set out in the field. In 1893 a striking difference was noticed between plants set out from the original hotbed and those transplanted to the cold frame prior to setting out. The plants taken to the field from the cold frame were stalkier, stronger, and grew more rapidly than those set out from the first seed bed, and they were not disturbed very much by being transplanted, but readily established themselves in their new location. The plants taken directly from the hotbed to the field were much slower in taking root and many of them had to be replaced.

In 1897 plants were transplanted to a second hotbed before setting them out in the field. The results showed that this practice gave stalkiness and vigor to the plants and materially reduced the number lost in transplanting to the field. This method is recommended for eastern Ontario and the Province of Quebec.

A vast amount of experience has of course been obtained in all of the tobacco districts in this practical matter of the seed bed. The old practice of growing plants in protected areas in the forest has been very generally superseded by using plant cloth for covering or by hotbed sash, or even by starting the plants in greenhouses.

In certain districts considerable trouble and loss have been experienced from certain fungous diseases. To prevent these, the soil used for the plant bed has been sterilized with boiling water, hot stones, or, preferably, with steam under high pressure. The method of steaming is quite feasible where there is a power plant from which steam can be obtained and is to be recommended where fungous diseases give any serious trouble in the plant bed.

Further investigations along this line are needed, both to ascertain to what extent injuries of this kind are felt and the cost of sterilizing the soil under the different methods which are used in horticultural work.

Further investigations are also needed in the line of protection against insects both above and below ground. Also investigations are necessary on methods of treating the plants and preparing them for the field. There are questions on the treatment of the plants in the seed bed, such as the matter of watering, which should be carefully considered; also the very important subject of the kind of soil best adapted—whether it should be mixed with manures and fertilizers, what kinds, and to what extent. The production of a vigorous, well-formed plant for setting out is a subject which deserves the most careful consideration.

The size, specific weight, and condition of ripeness of the seed, as well as the method of planting, have a very important bearing upon the crop, as horticulturists have shown with a number of crops.

VARIETIES OF TOBACCO.

At the North Louisiana Station[1] at Calhoun ten varieties of tobacco, namely, Conqueror, Hester, Long-leaf Gooch, Ragland Improved, Sweet Oronoko, White Burley, Comstock Spanish, Persian Rose, Improved Havana, and Brazilian American, were tested in 1892. Of these, Comstock Spanish, Persian Rose, Improved Havana, and Brazilian American are cigar-leaf varieties, and the rest are designated as bright-leaf varieties. On fertilized, red, sandy land the yields of cured tobacco per acre ranged from 900 to 1,530 pounds, and on unfertilized, red, sandy soil, from 399 to 1,200 pounds; on fertilized, gray, sandy soil the range of yield was from 1,050 to 1,680 pounds; on unfertilized, gray, sandy soil, from 810 to 1,170 pounds; on fertilized new land, from 120 to 600 pounds; and without the application of fertilizers, from 60 to 420 pounds. The bright-leaf varieties, with the exception of White Burley, produced a leaf which cured a lemon yellow, but the leaf of the cigar varieties cured too bright. The bright-leaf varieties succeeded best, Hester and Ragland Improved leading, with Conqueror, Long-leaf Gooch, and Sweet Oronoko closely following. The cigar varieties produced lighter yields and a poorer quality of leaf. The use of fertilizers improved the quantity and quality of the crop.

The results of tests made in 1893[2] showed that Conqueror, Long Leaf Gooch, Hester, Oronoko, and Ragland Improved cured brighter than other bright-leaf varieties, and that Vuelta de Abajo, Havana Seed-leaf, Imported Havana, Choice Havana, Little Dutch, and Pumpelly produced a leaf of greater silkiness and finer texture than other cigar varieties tested.

In 1895[3] it was found that White Stem Oronoko, Little Oronoko, Sweet Oronoko, Oak Hill Yellow, Hyco, Long-leaf Gooch, and Ragland Improved cured bright yellow more readily and uniformly than other varieties of bright-leaf tobacco grown in the experiment. During the same season the cigar varieties, Improved Havana, Connecticut Seed-leaf, and Little Dutch were grown at the Louisiana State Station at Baton Rouge. Improved Havana yielded a softer leaf and produced the largest percentage of wrappers; Connecticut Seed-leaf stood next in value, and Little Dutch last. The leaves of Little Dutch were too dark and heavy for cigar wrappers, as would be expected. No investigations seem to have been made of the qualities after fermentation, which is the only condition under which cigar types can be judged.

Several varieties of tobacco from Virginia, North Carolina, Florida, Connecticut, and Cuba were grown at the Alabama State Station in 1892.[4] The Cuban varieties matured first and were ready for cutting

[1] Louisiana Stations Bul. No. 20, 2d ser.

[2] Ibid. No. 25, 2d ser.

[3] Ibid. Nos. 33 and 34, 2d ser.

[4] Alabama State Station Bul. No. 44.

early in August, but wet weather had forced their growth and the product was poor in quality. The varieties from Virginia, North Carolina, and Connecticut did not ripen until September. A number of cigar varieties were grown in 1894.[1] Of these, Comstock Spanish produced a large, bright, thin leaf of good cinnamon color and large enough for wrappers, and Connecticut Seed-leaf a fine leaf somewhat lighter in color and smaller in size. Havana Seed-leaf and Havana produced fillers and binders. The leaf produced by Brazil Gold-leaf was thin and silky and brighter in color than the leaves produced by any of the other varieties grown. All these varieties had a decided cigar flavor with the exception of Brazil Gold-leaf.

From 1891 to 1893, inclusive, the Maryland Station[2] made a comparison of improved and introduced varieties of tobacco and the common or native sorts grown within the State. The following varieties were grown: Bonanza, Boyer or Tall Pear Tree, Bradley Broad-leaf, Broad-leaf Thick-set, Bullion, Climax, Connecticut Seed-leaf, Conqueror, Gold-finder, Havana, Hester, Hybrid Havana, Hyco, Lancaster County Seed-leaf, Long-leaf Gooch, Long Red, Narrow-leaf Thick-set, Oronoko White Stem, Pennsylvania Seed-leaf, Persian, Red Burley, Saffrano, Thesis, Tilley, Tuckahoe, White Burley, Yellow Oronoko, Yellow Pryor, and Zimmers Spanish. The best results were obtained from the varieties ordinarily grown in Maryland and from seed produced within the State.

Experiments carried on at the Colorado Station[3] in 1889 led to the conclusion that nothing but Havana Seed-leaf should be grown in that region. Tobacco from seed grown at the station was found to be much inferior to that grown from imported seed. Since that time no further work on tobacco has been reported by the station.

Among the earliest and best yielding varieties tested at the Central Experimental Farm at Ottawa, Canada,[4] were White Burley, Connecticut Seed-leaf, Pennsylvania Seed-leaf, Yellow Prior, Climax, Yellow Mammoth, Yellow Oronoko, Saffrano, Brazilian, and Canadian. In 1896 White Burley had matured, when a frost in September greatly injured later sorts. Connecticut Seed-leaf and White Burley are reported as being extensively grown in the Province of Quebec and in western Ontario.

In connection with a chemical study of the tobacco plant by the Virginia Experiment Station[5] in 1892, it was found that Bradley Broad Leaf and Yellow Oronoco contained a larger proportion of leaf than Gold Finder or White Burley. In these varieties the leaves comprised 59.77 and 60 per cent, respectively, of the total weight of the plant,

[1] Alabama State Station Bul. No. 64.
[2] Maryland Station Bul. No. 26.
[3] Colorado Station Bul. No. 10.
[4] Canada Cent. Expt. Farm Bul. No. 30.
[5] Virginia Station Bul. No. 14.

and the stalks 21 and 20 per cent. The average for all four varieties was 55 per cent of leaf, 21.9 per cent of stalk, and 23.1 per cent of root.

In planning future work on the varieties of tobacco it is very important to keep in mind the purpose for which the tobacco is intended. The kind of tobacco grown in any district depends in part upon the climatic conditions and in part upon the character of the soil. The industry has become so highly specialized that a nondescript tobacco has very little market value at the present time. In testing varieties, therefore, consideration should be given in the first place to the type of tobacco adapted to the locality and to the soil and the grade which the climatic conditions and soil may reasonably be expected to produce. For example, in the Connecticut Valley the most important question is, What is the best variety for producing a thin wrapper leaf of from 14 to 18 inches in length, having certain characteristics which are possessed by the Sumatra wrapper, the present standard of excellence for cigar wrappers in this country? On the heavier limestone soils of Pennsylvania and in the Ohio district, where a filler type is grown, the question is, What variety will give the small, highly-flavored leaf, approaching the Cuban tobacco in quality, in flavor, and in aroma?—the Cuban-leaf being the present standard for filler tobacco for cigars in this country.

One difficulty the experiment stations have found in the tobacco investigations is the fact that the finest qualities of the leaf are developed only after certain fermentation or other changes have taken place in the cured leaf. Most of the stations have not been prepared to manipulate the tobaccos so that a reliable estimate of their commercial value could be given.

INFLUENCE OF DISTANCE IN PLANTING ON THE YIELD AND THICKNESS OF THE LEAF.

At the Wisconsin Station a study of the relation of distance of planting to yield and thickness of leaf was made in 1894 and 1895.[1] In 1894 plants were set 20 inches apart in rows 31 and 36 inches apart and 24 inches apart in rows 42 inches apart. Close planting increased the yield, and the plants nearest together in the row produced a thinner leaf than plants set farther apart, but lessening the distance between the rows did not have this effect. A distance of 31 inches between the rows was sufficient for the full development of the plants. The surface area of the cured leaves per pound from the closest planting was 42.01 square feet, and from the widest planting 40.86 square feet.

In 1895 experiments were made with a view to ascertain to what extent close planting may be advantageously practiced. The plants were grown in rows 1, 1½, and 2½ feet apart with the distance between

[1] Wisconsin Station Rpts. 1894 and 1895.

plants in the row 1, 1, 1½ feet, respectively. In this experiment the surface area per pound of cured leaf was 60.64 square feet for the closest planting, 48.34 square feet for the next closest, and 47.40 square feet for the widest planting. The percentage of fillers produced ranged from 10.19 per cent for the widest planting to 16.40 per cent for the closest planting.

Close planting gave a large increase in yield and diminished the size and thickness of the leaf. The difference in the size and thickness of the leaf between plants grown 1½ by 2½ and those grown 1 by 2½ feet was not so marked as the difference in the yield, and this effect is considered as showing that planting 1 foot apart in the row was not too close for Wilson Hybrid, the variety grown in this experiment.

The experience of the Massachusetts Hatch Station[1] with regard to distance of planting was that planting 3 feet 4 inches by 1 foot 8 inches and 2 feet 8 inches by 2 feet gave better returns than planting 3 feet by 1 foot 6 inches. The author concludes that too close planting interferes with the development of the leaves, while too large spaces between plants tend to produce coarse leaves.

The Florida growers have shown the great importance of the proper distance in planting in the improvement of the quality of tobacco. Mr. M. L. Floyd[2] briefly cites the methods used by the Florida growers:

> In order to improve the tobacco and adapt it to the trade demands, these concerns have indulged in all sorts of experiments, some of which have proved quite expensive. However, they have met with such a degree of success as to warrant them in continuing the experimental work. There were many questions to be settled. First of all, what seed should be used. To settle this question seed was obtained and tried from every part of the country. This point, however, was soon determined and now there are only two varieties grown in the State—Sumatra and Cuban—the Sumatra giving the style required for the wrapper and the Cuban giving the filler qualities nearest the requirements of the trade. As each of these tobaccos possesses the quality and style needed, the kind of soil best suited to each was the next point to be settled; then the proper fertilizer, the quantity necessary, and the proper cultivation had to be found out by numerous experiments. At first it was thought that but little fertilizer of any kind should be used. The tobacco was set out early, given a distance in the drill of about 24 inches, and topped low; that is, not more than twelve or fourteen leaves were allowed to each stalk. The result was that the plants produced large, coarse, undesirable leaves. The next step was to give the tobacco less distance in the drill; 18 inches were tried. The result was better, but not satisfactory. From time to time changes were made until now the plant is given 14 inches, the fertilizer is doubled, and the tobacco is topped higher, allowing at least sixteen leaves to each stalk. The result is that the leaves are of the desirable size and finer in quality and appearance.
>
> For a long time the cultivation was continued until the time of harvesting, but this was decidedly wrong. The writer has seen fields of tobacco plowed that were ripe and ready to be harvested, and in consequence the tobacco turned green and

[1] Massachusetts Hatch Station Bul. No. 47.

[2] Report No. 62, U. S. Department of Agriculture, Cultivation of Cigar-leaf Tobacco in Florida, p. 22.

started a new growth. This generally increases the yield, but almost totally destroys the quality of the tobacco. At present the cultivation stops as soon as the plants are topped.

When the Sumatra seed was first introduced into Florida, the land selected, the amount of fertilizers used, and the methods of cultivation and harvesting employed were the same as those practiced in growing the Cuban variety. With this treatment Sumatra proved to be an absolute failure; many abandoned the seed, while others continued to experiment. It was soon found that the soil had to be exceedingly rich, the growth quick; that low topping was ruinous, and that each stalk should have from twenty-four to thirty leaves, according to the strength of the soil. When the land was exceedingly rich it was found best not to top at all, but to allow the plants to go to bloom. Then the leaves would be of desirable size, thin and smooth; whereas if topped the leaves would curl and thicken. This tobacco is also crowded into the drill, the plants being given only from 12 to 14 inches. The growth is rapid; the top leaves soon serve as a shade for the middle and lower leaves, and the results have been most gratifying. New land proved to be more desirable for this variety of tobacco, and it was noticed that when trees were left standing in the field the plants shaded by trees were far superior to the plants not so shaded. From this the idea of building artificial shade had its birth. It was also found that no good results could be obtained if the plants were cut, but the leaves should be primed off just as they ripen, and at a very early stage of ripeness.

Further experiments along these lines are very much to be desired, but the purpose of the investigation should be determined beforehand and the work should tend toward certain ends. For example, to use an illustration already referred to, the Connecticut growers are interested in the production of a fine wrapper leaf of moderate size, small veins, elastic, and with very little flavor. The size of the leaf, thickness, elasticity, and size of the veins may all be more or less modified by giving space or by crowding in the row. The undesirable qualities of the Connecticut wrapper should be recognized, as has been done in the case of the Florida tobacco, and such qualities eliminated by attention to just such conditions as the distance apart in the row and the height at which the plants should be topped. On the heavier soils of Pennsylvania, on the other hand, efforts should be directed to the production of a highly flavored leaf of moderate size. These are qualities which can also be sensibly affected by the distance of planting and by the time and manner of topping. In the same way in the development of the tobacco industry in the export and manufacturing districts, the undesirable qualities in the leaf may often be eliminated by a change in the method of planting, cultivation, or topping of the tobacco.

FERTILIZER EXPERIMENTS.

Fertilizer tests with tobacco were conducted at the Kentucky Experiment Station during several seasons. The results of experiments made in 1889[1] indicated that muriate of potash and sulphate of potash gave equally good results as fertilizers for tobacco and that nitrate of soda

[1] Kentucky Station Bul. No. 28.

produced a better quality of leaf than other forms of nitrogen. A test with complete and incomplete fertilizer applications for tobacco was made in 1892.[1] A yield of 1,460 pounds of cured leaf per acre was obtained from an application of 80 pounds of nitrate of soda, 80 pounds of dried blood, 160 pounds of muriate of potash, and 140 pounds of double superphosphate per acre and a yield of 1,620 pounds was obtained from an application of double these amounts. An application of 160 pounds of muriate of potash per acre resulted in a yield of 1,390 pounds of cured leaf but the crop was poor in quality. Potash applied alone gave better returns than when applied with nitrate of soda and dried blood or double superphosphate. The complete fertilizer mixtures produced the best yields and the heavy application the best financial results.

In 1893[2] fertilizers were used on soil in a good state of fertility. An application of 300 pounds of carbonate of potash and magnesium, 160 pounds of nitrate of soda, and 140 pounds of double superphosphate per acre increased the yield of cured leaf by 255 pounds per acre and, when 160 pounds of muriate of potash was substituted for the carbonate of potash and magnesium, the yield was increased 265 pounds. Incomplete fertilizer mixtures were least effective.

In 1895[3] the experiments were conducted under rather unfavorable conditions. The author concludes from the results obtained that satisfactory results may be obtained on worn Kentucky soils by applying potash fertilizers, especially when used in connection with nitrogenous fertilizers.

The results obtained in 1896[4] confirm the conclusions of the previous season.

The Maryland Station conducted fertilizer tests in different tobacco-growing sections of Maryland in 1891[5] and 1892. Dissolved South Carolina rock and dissolved bone black proved to be profitable sources of phosphoric acid, and high-grade sulphate of potash followed by cotton-seed hull ashes was found to be the best form of potash. The author concludes that nitrogen should be applied in two forms: One-half as nitrate of soda and the other half in some organic form, such as dried blood or tankage.

In 1892 the North Louisiana Experiment Station at Calhoun[6] conducted fertilizer experiments with tobacco on red sandy and gray sandy soil. Potash had little or no effect on the increase of the crop, but nitrogen either in the form of nitrate of soda, sulphate of ammonia, cotton-seed meal, or dried blood caused a marked increase in the quantity produced. An application consisting of cotton-seed meal, acid

[1] Kentucky Station Bul. No. 45.
[2] Ibid. No. 55.
[3] Ibid. No. 63.
[4] Ibid. No. 66.
[5] Maryland Station Bul. No. 26.
[6] Louisiana Stations Bul. No. 20, 2d ser.

phosphate, and sulphate of potash produced the best quality of leaf. These tests were continued in 1893,[1] and the results indicated that nitrogen was needed most, while potash was the least necessary. Complete fertilizer mixtures gave the best results, in some cases increasing the yield over 100 per-cent as compared with a crop grown without the use of fertilizers.

The results of the work carried on in 1894 and 1895[2] confirm the conclusions drawn from the experiments of the preceding seasons and indicated that cotton-seed meal was the best and cheapest source of nitrogen for the tobacco crop in that region. Since potash had shown itself least effective in this series of experiments it is concluded that cotton-seed meal and acid phosphate is the best tobacco fertilizer mixture for the soils on which the experiments were made.

The effects of different fertilizers on tobacco were studied at the Virginia Station[3] in 1890. Five plats fertilized with complete fertilizers, all of the same cost per acre, were compared with an unfertilized plat. As a source of nitrogen, dried blood gave the largest yield and the best financial returns. Dried blood in connection with nitrate of soda also gave good results, and where these fertilizers were applied, either in combination or separately, the tobacco fired very little as compared with the tobacco grown on the unfertilized plat. There was also much more stalk rot on the unfertilized plat than on the other plats. The plat which had received sulphate of ammonia, sulphate of potash, and acid phosphate suffered most from field fire and gave smaller returns than any other of the fertilized plats. The tobacco grown without fertilizers ripened from ten days to two weeks later than the tobacco grown with fertilizers.

In 1893 the Pennsylvania Station[4] made some experiments to determine the relative values of various fertilizers for tobacco. The use of fertilizers increased the size of the wrapper leaves, and an application of double carbonate of potash and magnesium, contrary to the claim sometimes made for it, had no restraining effect on the size of the leaf. The loss in sweating the crop was greatest where barnyard manure had been used. Phosphoric acid in the form of dissolved bone black showed a tendency to thicken the leaf, and nitrate of soda produced a very dense leaf. Double carbonate of potash and magnesium produced a thinner web than sulphate of potash, but had little effect upon the vein. As to burning quality, no decided differences were noticed, except that the duration of glow was least in the crop fertilized with barnyard manure.

In connection with soil tests made by the North Carolina Sta-

[1] Louisiana Stations Bul. No. 25, 2d ser.
[2] Ibid. Nos. 33 and 41, 2d ser.
[3] Virginia Station Bul. No. 12.
[4] Pennsylvania Station Bul. No. 30.

tion[1] in 1891 and 1892 it was found that the application of fertilizers furnishing nitrogen and phosphoric acid produced the best quality of leaf, while fertilizers supplying nitrogen and potash gave the best results in yield and total value of crop. Potassium chlorid as a source of potash was more profitable than kainit or potassium sulphate, but the use of the sulphate resulted in a better quality of leaf as compared with the other forms of potash.

Field experiments with tobacco were conducted by the Massachusetts Experiment Station[2] at three different points in the Connecticut Valley within the State during three seasons, from 1893 to 1896. The different fertilizers applied had a greater effect upon the quality of the crop than upon the yield. Cotton-seed meal, linseed meal, and castor pomace, when used in connection with an amount of nitrate of soda or nitrate of potash sufficient to furnish one-fourth of the nitrogen needed by the crop, proved equally good as sources of nitrogen. Nitrate of soda applied with acid phosphate or dissolved bone black produced a better quality of tobacco than nitrate of potash under the same conditions. Cotton-seed hull ashes, followed by high grade sulphate of potash, were observed to be the most valuable sources of potash. Nitrate of potash produced excellent results when used in connection with an alkaline phosphate, such as phosphoric slag meal or with carbonate of potash and magnesia. Potash-magnesia sulphate as the main source of potash did not give encouraging results. The author classifies the fertilizer mixtures used in these experiments as follows:

First class.

Nitrate of soda, cotton-seed hull ashes, and castor pomace.
Nitrate of soda, cotton-seed hull ashes, and cotton-seed meal.
Nitrate of potash, cotton-seed hull ashes, and cotton-seed meal.
Nitrate of potash, carbonate of potash-magnesia, and phosphatic slag.

Second class.

Nitrate of soda, high grade sulphate of potash, cotton-seed meal, and dissolved bone black.
Nitrate of soda, high grade sulphate of potash, linseed meal, and dissolved bone black.
Nitrate of soda, high grade sulphate of potash, castor pomace, and dissolved bone black.

Third class.

Nitrate of potash, potash-magnesia sulphate, cotton-seed meal, and dissolved bone black.
Nitrate of potash, potash-magnesia sulphate, castor pomace, and dissolved bone black.

[1] North Carolina Station Bul. No. 89.
[2] Massachusetts Hatch Sta. Bul. No. 47.

This classification is based on the difference in color and compactness of the ash of the tobacco grown with the different fertilizer applications. Since these differences were slight in several instances the classification is considered as somewhat arbitrary.

The most extensive series of fertilizer tests on tobacco reported by the experiment stations was made by the Connecticut State Experiment Station[1] in connection with the Connecticut Tobacco Experiment Company during the seasons of 1892 to 1896, inclusive. The experiments were conducted on 28 plats on which different fertilizers or different amounts of fertilizers were applied, and the conclusions drawn are based upon the average results for four or five years. An application of 210 pounds of nitrogen per acre, either in the form of cotton-seed meal or castor pomace, produced larger crops, a greater percentage of wrapper leaf, and a better quality of tobacco than an application of 175 pounds or 105 pounds of nitrogen. A comparison of cotton-seed meal and castor pomace as tobacco fertilizers showed that castor pomace produced on an average for five years 25 pounds of wrappers more per acre than cotton-seed meal, but the average quality of leaf raised with cotton-seed meal was somewhat better than that of leaf grown with castor pomace. Linseed meal as a source of nitrogen produced on an average for four years 157 pounds of wrappers per acre less than castor pomace and 65 pounds less than cotton-seed meal, but the quality of the leaf from the linseed-meal plat was decidedly better than from the other two. The average results of a comparison of dry-ground fish and cotton-seed meal, carried on for four years, showed that dry-ground fish yielded 257 pounds of wrapper leaf per acre less than cotton-seed meal, but in quality of product the plat fertilized with dry-ground fish ranked fourth among the entire number of plats, while the other plat ranked seventeenth. Dry-ground fish produced 56 per cent of wrappers in the crop, and the cotton-seed meal 63 per cent.

Applying one-half of a dressing furnishing 210 pounds of nitrogen per acre, in the form of nitrate of soda, when the crop was nearly half grown, instead of applying the whole amount of nitrogen in the form of castor pomace prior to setting out, the crop produced a heavier yield of tobacco suitable for wrappers, but it reduced the quality of the leaf so that there was no economy in the practice. The average yield for four years of tobacco fertilized with tobacco stems was 976 pounds of wrappers per acre, as compared with a yield of 681 pounds for the crop grown with stable manure, but the stable manure produced a better quality of leaf than the tobacco stems. Taking into consideration the results obtained with stable manure and cotton-seed meal the author recommends supplementing an application of stable manure

[1] Connecticut State Station Rpts., 1892, 1893, 1894, 1895, 1896, 1897.

with some quickly available form of nitrogen, such as cotton-seed meal.

A study was also made of the effects of various forms of potash on the quantity and quality of tobacco. The plats fertilized with some form of carbonate of potash produced a smaller yield than the average yield for all the potash plats, while the plats which received potash in the form of sulphate yielded more than the average. Sulphate of potash produced tobacco which had slightly heavier leaves, and which did not hold fire quite so long as tobacco produced by the use of some form of carbonate. In general the crops fertilized with pure carbonate of potash, wood ashes, double carbonate of potash and magnesia, and cotton-hull ashes were of better average quality than the crops fertilized with high-grade sulphate of potash and double sulphate of potash and magnesia, either with or without lime. The addition of lime had little effect on the quality of the leaf.

IRRIGATION OF TOBACCO.

The effects of irrigation on the product of tobacco were studied by the Wisconsin Station [1] during two especially dry seasons. In 1893 the crop was irrigated twice and the yield, as compared with the yield of unirrigated land, showed an increase of 23 per cent in the weight of the uncured crop, 33 per cent in the weight of the cured stalks, and 7 per cent in the area per pound of cured leaf. The weight of the total crop of cured leaves from the irrigated and unirrigated plats was practically the same, showing that the increase in the weight of the green crop was almost entirely due to the increase in the weight of the stalks. One hundred cured leaves of average size selected from tobacco grown under irrigation weighed about 13 per cent more than the same number of leaves similarly selected from the plants grown without irrigation.

In 1894 only one irrigation was given. The increase due to irrigation in the weight of the green crop was 7.35 per cent, in the weight of the cured leaves 6.96 per cent, and in the area per pound of cured leaf 1.7 per cent. After the crop had been cured 800 sound leaves were selected from the plants grown with and without irrigation and weighed. The leaves from the irrigated plat weighed 2.92 per cent more than those from the unirrigated plat. It was noticed that the plants were more readily broken down by heavy winds on the irrigated plat than on the other. A better yield of cured leaf was obtained in 1894 with one irrigation than in the preceding year with two irrigations. It was shown during the two seasons that irrigation perceptibly increased the yield and produced a thinner leaf, as com-

[1] Wisconsin Station Rpt., 1894.

pared with tobacco grown without irrigation, but that there was no other noticeable difference in the quality of the leaf.

A practical experiment on a commercial scale has been started in Florida in the irrigation of the Sumatra type of wrapper leaf. The first crop is reported to be of the finest quality that has ever been grown in the State, containing a larger proportion of first-class wrappers. The experiments are being continued and extended. Next year it is proposed by a single company to put 200 acres under the ditch. It is not only necessary in this case to provide the water supply, but the distance of planting, method of cultivation, and time and manner of topping must all be controlled in reference to the variety of tobacco planted and the grade it is proposed to produce—whether a wrapper or a filler leaf.

In the same line the practice of shading tobacco in Florida may be mentioned. This prevents the excessive evaporation from the plants as well as from the soil, and has had a marked effect in improving the quality of the wrapper leaf and in increasing the percentage of wrapper leaf in the crop.

An older method of irrigating in Florida, by the use of overhead sprays, was reported in Bulletin No. 13 of the Division of Soils. This method is not believed to have been as economical or as successful as the present method of subirrigation from wooden troughs laid in the ground.

INFLUENCE OF TIME OF HARVESTING ON THE YIELD AND THICKNESS OF THE LEAF.

Experiments were undertaken at the Wisconsin Station[1] in 1895 with a view to determining whether the tobacco leaf increased in size and thickness and whether the loss in curing diminishes when the plants are allowed to stand a considerable time after topping.

Tobacco plants were topped August 2 and 6 and the leaves were picked at different times, varying from eighteen to thirty-two days after topping. Upper leaves were selected as samples from which data were determined. The results indicate that the thickness and dry matter of the leaf tended to increase up to thirty-two days after topping, and the yield showed a tendency to increase in like manner. Cured samples which had been harvested eighteen days after topping had a weight of 459.2 grams and an area per pound of cured leaf of 47.81 square feet as compared with the weight of 577.55 grams and an area per pound of cured leaf of 41.39 square feet for cured samples harvested twenty-seven days after topping. There was no material difference in the percentage of loss in curing between the various samples.

[1] Wisconsin Station Rept., 1895.

Practical growers in all of the tobacco districts have for years experimented upon this subject and very marked results have been attained in the production of an article suited to the market demands. It is quite possible to vary the commercial grade and influence the price considerably by harvesting the crop at different stages of ripeness. This has been taken advantage of in many cases in catering to many trade requirements. It is one of the methods by which the quality of the tobacco can be sensibly controlled.

EFFECT OF PRIMING TOBACCO PLANTS.

Priming consists in removing the leaves of the tobacco plant as they mature.

It was noticed in connection with curing experiments at the North Carolina Station[1] that priming had a marked effect on the growth and chemical composition of the upper leaves. Removal of the lower leaves caused an increased growth in the upper leaves and with it an increase in percentage of nitrogenous matter and nicotine. The quality of the product was thus somewhat lowered by priming, but the gain in weight more than compensated for the loss in quality.

Priming the leaves from the stalk as they ripen is believed by many practical tobacco growers to be the proper method of harvesting the cigar and cigarette types, for in this way alone can the tobacco be saved just at the proper stage of ripeness. Priming does not impair, but improves, the quality. The increase in pounds is simply due to the fact that the upper leaves are allowed to remain on the stalk until they are fully developed and matured. The priming of tobacco is more expensive than cutting the stalk, as more labor is required, but the improvement in quality fully warrants this additional cost.

The method of priming is very generally used now with the bright yellow leaf of Virginia and North Carolina, and with the Sumatra type of wrapper leaf in Florida. It has the advantage that the leaves are uniformly matured when they are hung in the barn, and the finished crop is therefore of a more uniform character. In priming it is usual to go over the crop three or four times, finally cutting the stalk with the top leaves attached.

EXPERIMENTS IN TOPPING TOBACCO.

The Central Experimental Farm at Ottawa, Canada,[2] conducted experiments in topping tobacco plants in order to determine how the time of topping and the number of leaves left on the plants affect the yield. The plants were topped July 20 and 26 and August 2, and on each date one plat was cut back to 9 leaves and another to 11 leaves per

[1] North Carolina Station Bul. No. 90a.

[2] Canada Experimental Farm Report, 1897.

plant. Early topping caused the plants to throw out suckers freely, but this tendency diminished as the topping was done later. It was found sufficient to remove the suckers from the later topped plants once, while from the plants topped on the two earlier dates they had to be removed at two different times. The larger yields were obtained from the latest topping and the greater number of leaves per plant.

The time for topping a tobacco plant is when the seed bud has well put out. If the soil is rich and the tobacco has the proper distance only the seed bud should be taken out; all leaves should be allowed to grow. It is often necessary to remove the suckers three or four times after topping.

The time and manner of topping has a great influence upon the character of the leaf produced. As a rule the earlier a plant is topped and the lower it is topped the heavier, richer, and darker-colored the leaves become. This is a decided advantage for some crops, but a disadvantage to others. In the production of the finest quality of Sumatra wrappers in Florida the practice has recently grown up of topping very high, and, indeed, in wet seasons or on heavy soils, where the plants are making a luxurious growth, the plant is allowed to go to seed in order to keep the leaves as small and thin as possible.

YIELD OF TOBACCO.

The yield of tobacco, like that of other crops, is the product of all the factors of growth and, as these are not constant, but vary considerably with time and place, the yields vary at different times and in different sections of the country. The results obtained at different experiment stations in connection with experimental work are here briefly noted:

At the North Louisiana Experiment Station[1] at Calhoun in 1892 the average yields of bright leaf and cigar varieties on different experimental plats varied from 712 to 1,280 pounds of cured leaf per acre, respectively, on fertilized and unfertilized plots; in 1893[2] an acre of bright tobacco yielded 592 pounds of cured leaf, and 11 varieties of cigar tobacco, grown on fertilized red sandy soil, yielded on an average 1,046 pounds per acre, while an acre of land at Shreveport, La., under the management of the station, yielded at the rate of from 1,400 to 1,600 pounds of cured cigar leaf and from 1,600 to 1,800 pounds of bright leaf; in 1894[3] the average yields of cured leaf per acre of cigar and bright leaf varieties in connection with soil, variety, and fertilizer tests, ranged from 359 to 1,086 pounds per acre; and in 1895[4] the results of similar work varied from 505 to 788 pounds per acre in the yield of cured tobacco of yellow leaf and cigar varieties.

[1] Louisiana Stations Bul. No. 20, 2d ser.
[2] Ibid. No. 25, 2d ser.
[3] Ibid. No. 33, 2d ser.
[4] Ibid. No. 41, 2d ser.

At the Alabama State Station[1] in 1893, cigar varieties on upland and bottom sandy soils ranged in yield from 439.4 to 1,505.4 pounds, and plug tobaccos from 575.4 to 1,744.6 pounds of cured leaf per acre.

The North Carolina Station[2] reports yields of cured leaf ranging from 665.5 to 1,542.7 pounds per acre.

Long-leaf Gooch tobacco, grown in connection with fertilizer tests at the Virginia Station in 1890,[3] yielded 762 pounds of cured tobacco on the check plat and 1,035 pounds per acre on the most productive fertilized plat.

Plat experiments with fertilizers for tobacco at the Maryland Station[4] in 1892 resulted in yields of cured tobacco per acre varying from 440 on the unfertilized to 820 pounds per acre on the fertilized plats.

At the Kentucky Station[5] in 1895 White Burley yielded from 555 to 1,499 pounds of cured leaf per acre, and in 1896[6] the yields of experimental plats varied from 500 to 1,295 pounds of cured leaf per acre.

In experiments carried on by the Massachusetts Hatch Station,[7] at Hatfield, Agawam, and Westfield, Mass., for three successive years, the yields of cured leaf varied from 1,379 to 1,648 pounds per acre. The percentage of wrapper leaf in these crops ranged from 21.2 to 69.6 per cent.

In connection with the fertilizer experiments carried on for five years in succession by the Connecticut State Station,[8] the yield for all plats for the entire period averaged 1,685 pounds of assorted leaf per acre. The average yields for the different years ranged from 1,569 to 1,876 pounds. The heaviest yield obtained from any one plat was at the rate of 2,280 pounds per acre. The average yield of wrappers for the five years was 60.7 per cent of the total yield, with a range from 47.2 to 66.2 per cent for the different seasons. On some plats as high as 78 per cent of the product was suitable for wrappers.

Estimated yields, based on the results obtained on experimental plats at the Wisconsin Station in 1893 and 1894,[9] varied from 1,484 to 3,841.5 pounds of cured leaf per acre.

On small experimental plats at the Central Experimental Farm, Ottawa, Canada,[10] the rate of yield has been estimated in different seasons from about 1,500 to 2,500 pounds of cured leaf per acre.

The question of the actual yield of tobacco is an important consideration under certain circumstances, but is a matter of little interest in other cases. In the cigar districts, particularly, the influence of quality on the price is so great that the actual yield is hardly a matter for consideration. At the same time other factors enter in, as the price

[1] Alabama State Station Bul. No. 54.
[2] North Carolina Station Bul. No. 89.
[3] Virginia Station Bul. No. 12.
[4] Maryland Station Bul. No. 26.
[5] Kentucky Station Bul. No. 63.
[6] Ibid. No. 66.
[7] Massachusetts Hatch Station Bul. No. 47.
[8] Connecticut State Station Rpt., 1897.
[9] Wisconsin Station Rpts., 1894 and 1895.
[10] Canada Central Exptl. Farm Bul. No. 30.

of labor in the grading and sorting of the finer grades. It is often more profitable to raise a large quantity of inferior leaf than to raise a small weight per acre of a finer leaf which can not be economically sorted. This question, therefore, depends to a very great extent upon local conditions, and especially upon labor conditions.

DISEASES OF TOBACCO.

The diseases to which most attention has been given are those which manifest themselves during the curing process and which are commonly known as stem rot and pole burn. This latter disease is also referred to as "pole sweat" and "house burn." Both of these diseases were observed and studied by the Connecticut State Station during several seasons. As observed by this station,[1] pole burn makes its appearance as small dark spots on the surface of the leaf near the veins and midrib, where moisture is most abundant. These spots rap idly increase in size, soon becoming confluent, and within thirty-six to forty-eight hours the whole leaf may be affected and the entire contents of the curing barn destroyed. The tobacco changes in color from a green yellow to a dark brown, or almost black, loses its fine texture, and reaches such a stage of decay that the leaves are separated from the stalk by their own weight. From investigations made at the station and results obtained by other investigators of this same subject, the author infers that the disease is due primarily to a fungous growth which attacks the leaf on the surface and gives access to a bacterial process of decay by disintegrating and partially destroying the leaf tissue.

Cultures of the bacteria which caused this rapid decay of the leaf were studied in the laboratory, and it was ascertained that moisture and temperature have a marked effect on the activity of these organisms. Decreasing the amount of moisture decreased their vitality, and a temperature up to 70° F. or even 90° F. favored their development, while temperatures of over 100° or 110° and below 35° or 40° temporarily or permanently checked their vitality. Attempts to inoculate thoroughly cured tobacco with the bacteria were unsuccessful. The author concludes from his study that pole burn can be prevented by a proper regulation of moisture and temperature.

In 1893,[2] although conditions were most favorable for curing tobacco, an experiment was conducted to test the effect of artificial heat on the temperature and relative humidity of the air in a tightly-closed barn filled with green tobacco. A number of observations were made in each case and average results determined. The temperature of the outside atmosphere was 57° F. and the relative humidity 70°. Inside the barn the temperature was 54° and the relative humidity 82°. Opening the end doors and the lowest row of ventilators in fair weather

[1] Connecticut State Station, Rept., 1891. [2] Ibid. 1893.

brought the temperature inside the barn, 6 feet above the floor, to within one degree of the temperature of the air outside, and reduced the relative humidity from 91° to 86° within half an hour. For the test with artificial heat the barn was tightly closed and fire started in two of the four furnaces, thus using only one set of flues. One hour after starting the fire the relative humidity was 69° and the temperature 71.5° F. 6 feet above the barn floor. "By using only half the available heating facilities for one hour, the relative humidity of the interior of the barn at a height of 6 feet from the ground was reduced from 91° to 69°. * * * In conclusion we are justified in considering that, under the atmospheric conditions most favorable to the development of 'pole sweat,' the temperature and moisture in the interior of a closed barn can be so regulated by artificial heat as to reduce to a minimum the liability of curing tobacco to damage from fungi or other like organisms."

No special experiments were made with stem rot, but the author states[1] that this fungus disease which frequently affects the stems of the plants in the last stage of curing seldom matures in the cured stalks, owing to their dryness at this time. As a remedial measure it is suggested that when the crop is cured all stems and refuse attacked by stem rot be burned before the fungus has matured and the barn be fumigated with sulphur immediately after curing a crop and again before the harvesting of the next season's crop. "If this be done * * * the danger from stem rot would be largely decreased if not entirely obviated."

EXPERIMENTS IN CURING TOBACCO.

Experiments with different methods of curing tobacco have been conducted by the experiment stations of a number of tobacco-growing States. In a series of experiments made in Maryland and reported by the Maryland Experiment Station[2] tobacco was air and flue cured in a frame barn and flue cured in a log barn. Owing to more favorable conditions of humidity, flue curing gave better results in the frame barn than in the log barn. Results in general were favorable to flue curing as compared with air curing.

At the North Carolina Station in 1891,[3] the ordinary method of cutting down the plant and curing it with the leaves on the stalk proved less profitable than curing by the Snow process, in which the leaves are cut from the stalk as they ripen and cured separately. By the ordinary method 326 pounds of cured leaves were obtained from 2,114 pounds of fresh leaves and stalks, and by the Snow process 454 pounds from 2,109 pounds of green plants. The net financial returns amounted

[1] Connecticut State Station Rpt., 1891. [2] Maryland Station Bul. No. 26.
[3] North Carolina Station Buls. Nos. 86 and 90a.

to $32.89 for the stalk-cured, and $53.55 for the leaf-cured or Snow process. The tobacco cured by the leaf process was better in quality than the leaf cured on the stalks. This effect is ascribed to be due to harvesting the leaves as they became mature, while by the stalk process many of the lower leaves were overripe and the upper leaves still green at the time of cutting. Handling the leaves on the stalks also caused a greater loss than handling them separately. It was found that the time and temperature required for curing leaves from different parts of the plant varied according to their ripeness, and that for this reason the leaf-curing proved the more desirable method, since the leaves cured at one time were all of the same degree of maturity and required like treatment to produce the best results in color, quality, and general appearance. The author states that carefully regulating the drying by artificial heat, as practiced in the Snow curing barn and old style log barn, reduces the fermentative changes in curing to a minimum. It is believed that in these experiments, owing to this fact, practically the whole amount of glucose present in the leaves remained unchanged in the cured product.

The record of temperature in leaf curing is given briefly as follows: The temperature in the barn on August 18, at 9 a. m., was 90°; at 10 a. m., 95°. On August 19, at 10 a. m., 100°; 11 a. m., 105°; 9.30 p. m., 120°. August 20, 10 a. m., 125°; 2 p. m., 130°; 10 p. m., 136°. August 21, 3 a. m., 140°; 6 a. m., 150°; 12 m., 120°, after which the temperature was allowed to fall rapidly and the next morning the tobacco was taken out of the barn. In this process the leaves lost 81.44 per cent of the green weight.

The Pennsylvania Station[1] found that on an average 72.70 per cent of the weight of the whole plant was leaf, and that the cured leaf constituted 15.80 per cent of the weight of the original leaf with stalk-cured tobacco and 14.40 per cent with leaf-cured tobacco. The percentage of leaf tissue was also somewhat greater in the stalk-cured product.

The Wisconsin Station[2] made a series of investigations on the curing of tobacco in 1894, and the results obtained were confirmed by the repetition of the experiments the following season.[3] It was found that the loss of water in curing was about 71 per cent of the weight of the green plant. The rate at which the water passed off increased gradually from the time the leaves were well wilted until their color was changing from yellow to brown. The water appeared to be eliminated by the leaves rather than extracted from them by drying. It is stated that the changes in the color of the leaf during the curing process were not directly due to the loss of moisture, but depended largely upon the degree of ripeness, the riper the leaf the lighter the

[1] Pennsylvania Station Rpt., 1894. [2] Wisconsin Station Rpt., 1894. [3] Ibid., 1895.

shade of brown when cured. From data obtained in this work the author considers it warrantable to conclude that tobacco should be cured in as moist an atmosphere as possible without incurring damage from pole burn. A temperature within the curing house not exceeding 75° F. and a degree of humidity among the plants represented by a wet bulb depression of 2° are regarded as suitable conditions. In order to maintain these conditions the author recommends that the plants should be evenly distributed in the curing house in order to equalize the humidity in the building, and that the ventilation of the curing house should be under perfect control, with a provision to regulate the humidity of the air by the use of artificial heat.

In connection with other experiments in 1895[1] the loss in curing leaves harvested on different dates, from August 24 to September 2, ranged from 85.5 per cent to 87.6 per cent. The percentage of loss in curing was not materially smaller in the later harvested leaves. In one case where the weight of the cured stalks was deducted in addition to the loss of water the loss in curing ranged from 90.77 per cent to 92.58 in four samples.

Experiments with tobacco culture were conducted for several years at the North Louisiana Experiment Station, at Calhoun,[2] and in connection with these the percentage of loss in curing the product was determined. The percentage of loss in curing bright leaf and cigar tobaccos grown with or without fertilizers on red sandy, gray sandy, or new land ranged from about 70 to 90 per cent, but the results did not show that the different types of tobacco or the different soils and methods of fertilization had any special influence on the loss in curing.

In 1897 the Connecticut State Station[3] made a test of curing tobacco on the stalk in a curing room in which the conditions of temperature and humidity were under control. The temperature never went above 88° and seldom over 82°, and the lowest point reached was 59°; but the average temperature for the coldest portion of the twenty-four hours, from 3 to 6 a. m., was 69°. The heat was kept uniform throughout the room, and before the leaves had come to color the humidity was such that they were perfectly limp and hung like damp cloths. The curing was continuous, an advantage derived from the control of the atmospheric conditions within the room. The results of the experiments were so satisfactory that it was repeated on a large scale in a curing barn. Here the results obtained, so far as the work was carried on, were even more satisfactory than in the curing room. The accidental burning of the barn and the tobacco prevented drawing any further conclusions.

[1] Wisconsin Station Rpt., 1895. [2] Louisiana Stations Buls., Nos., 20, 25, 33.
[3] Connecticut State Station Report, 1897.

FERMENTATION OF TOBACCO.

The changes going on in the fermentation of tobacco and their causes have not been studied very extensively by the experiment stations up to the present. The most attention in connection with this subject has been given to the loss or shrinkage in the weight of the leaves, and in several instances the chemical changes which take place during fermentation have been determined. In 1891 and 1892 the Connecticut State Station[1] compared the weight and chemical composition of cured and fermented leaves. The loss in the fermentation of upper leaves, short seconds, and first wrappers was 9.7, 12.3, and 9.1 per cent of their total weight, respectively. About three-fourths of the loss in the short seconds consisted of water; the upper leaves lost almost the same proportion in dry matter, and in the first wrappers the loss of dry matter was a little less than that of water. The nitric acid, ammonia, fiber, and starch content of the leaves was affected very little by the process of fermentation, and the chief loss of dry matter was found to have occurred in the nicotine, albuminoids and amid bodies, nitrogen-free extract, and ether extract. The upper leaves lost over one-third of their nicotine, the short seconds a little less than half, and the first wrappers less than one-sixth. Fermentation seemed to have been most active in the upper leaves, which lost over one-seventh of their nitrogen-free extract and one-fifth of their ether extract. The first wrappers, which constitute a large and the most valuable part of a good crop, lost only 5.8 per cent of their dry matter, this loss being mainly in the ash, nitrogenous matters other than nicotine, and nitrogen-free extract, which includes the "gum" of tobacco. The author does not consider the loss of ash as having been caused by the process of fermentation. The average results obtained by the fermentation of the various experimental crops of tobacco studied by this station for five successive years are of importance in this connection.[2] The average loss of weight due to fermentation in the crops of the different seasons ranged from 8.1 to 14 per cent, but the crop which lost most was not fermented satisfactorily. The average number of leaves per pound of short wrappers was 87 before fermentation and 92 after fermentation, and of long wrappers 64 when cured and 68 when the process of fermentation was completed. The largest number of fermented short wrappers and long wrappers per pound from any one plat was 113 and 98, respectively. It was found that the short wrappers had an average fire-holding capacity of 12 seconds before and 28.5 seconds after fermentation, and the long-wrapper leaves a fire-holding capacity of 9.2 seconds before and 23.9 seconds after they had been fermented.

[1] Connecticut State Station Rpt., 1892. [2] Ibid., 1897.

The Pennsylvania Station[1] found in 1894 that the loss in fermentation was greater with tobacco fertilized with barnyard manure than with tobacco grown with other fertilizers. Applications of double carbonate caused a greater loss in fermentation than the use of sulphate of potash. The smaller leaves lost more than the larger ones, which is considered due to the difference in degree of maturity. Injury from hail and rust is reported as having had no effect on the rate of fermentation.

The fermentation of tobacco is being investigated very thoroughly by the Department of Agriculture, and four reports have already been issued on the subject.[2] These will not be summarized here nor will further comment be made upon the practical development in this line as this has been fully discussed in the publications referred to which can readily be obtained.

COST OF PRODUCING TOBACCO.

The cost of growing tobacco has been studied by only three stations. By two of these stations only estimates are given. At the Georgia Station[3] in 1892 the cost of producing an acre of tobacco, including curing and grading, amounted to $42.07. The cost of producing an acre of cured tobacco at the South Carolina Station[4] in 1898 was $48.05, and, including the expense of preparing and marketing the crop, the cost of production is estimated at $70 per acre. The Colorado Station[5] estimates the cost of producing and marketing one acre of tobacco in Colorado at $78.50.

The cost of producing the Florida tobacco is considered by Mr. Floyd in Report No. 62 of the U. S. Department of Agriculture. He estimates the cost to the large Florida growers when all labor has to be hired at about 18½ cents per pound when cured, with an additional cost of 5 to 8 cents per pound for fermenting, grading, sorting, and packing. The actual outlay to the small farmer, who has much or all of the labor done by himself or the members of his family, is considerably less, but working on small quantities the fermentation and grading can not be so carefully done, and the product is not so valuable.

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[1] Pennsylvania Station Bul. No. 30.

[2] Farmers' Bul. No. 60, Methods of Curing Tobacco. Milton Whitney, 1898.

Report No. 59, Curing and Fermentation of Cigar-leaf Tobacco. Oscar Loew, 1899.

Report No. 60, Temperature Changes in Fermenting Piles of Cigar-leaf Tobacco. Milton Whitney and Thomas H. Means, 1899.

Report No. 62, Cultivation of Cigar-leaf Tobacco in Florida. Marcus L. Floyd, 1899.

[3] Georgia Station Bul. No. 19.

[4] South Carolina Station Rpt., 1898.

[5] Colorado Station Rpt., 1888.

CHEMICAL COMPOSITION OF THE TOBACCO PLANT.

The chemical composition of the tobacco plant has been studied by the stations from various points of view, The different parts of the plant have been analyzed to determine the amount of plant food contained in them. Studies have been made to ascertain the effect of curing and fermenting upon the composition of the leaf and stalk; and the composition of the refuse, such as tobacco dust and tobacco stems, has been determined to show its value as a fertilizing material. A number of analyses of tobacco ash are also reported. The most important results are here briefly summarized.

At the Colorado Station,[1] the analyses of the ash of a number of varieties of tobacco showed that the composition of the samples grown was similar to the average composition of tobaccos produced in Connecticut and elsewhere. One qualitative test for acids in the leaf was made, and acetic, pectic, citric, malic, and oxalic acids were found. The leaves also contained considerable quantities of resinous and fatty substances. The ash of Havana tobacco grown on poor soil was found to contain more than twice as much silica but considerably less lime, potash, and carbon dioxid than the same variety grown on rich soil.

A study of the occurrence of nitrates in tobacco at different stages of growth made at the North Carolina Station[2] pointed out that the nitrates are confined almost entirely to the stalk and stems in the young plants. During the later growth of the plant practically no nitrates were found. Samples of tobacco stems from different sources were analyzed by the station and compared. Stems of cigar tobacco from Missouri, Connecticut, and Ohio and stems of export tobacco from Virginia contained 0.83, 0.72, 0.60, and 0.54 per cent of nitrates, respectively, while stems of cigarette tobacco from North Carolina contained 0.15 per cent. No nitrates were found in North Carolina stems of chewing tobacco or in the dust from the North Carolina product. In general the total nitrogen content was smaller in North Carolina tobacco stems than in those obtained from tobacco grown in the other States mentioned. Whole leaf of North Carolina bright tobacco cured by the leaf-curing process contained 16.23 per cent of potash, while the same kind of tobacco cured by the stalk-curing process contained 21.81 per cent. Other variations in the composition of tobacco resulted from the two methods of curing, but it is believed all these differences in the chemical composition are due mainly to the manner and time of harvesting, and that in general the composition of tobacco cured by similar methods is not materially affected by separating the leaf from the stem before curing if the condition of the tobacco is the same when put into the barn.

[1] Colorado Station Bul. No. 10. [2] North Carolina Station Bul. No. 90a.

Analyses of parts of the tobacco plant at different stages of growth were made at the Virginia Station in 1894.[1] Nearly one-half of the ash of young plants consisted of potash, amounting to three times the content of lime. The percentage of ash in the leaf at four different stages was about the same, increasing slightly from topping until cured. The nitrogen content was nearly 1 per cent higher at the time of topping than when the leaf was cured, while the percentage of phosphoric acid showed very little change, being a little higher when the plants were topped than when cured. The potash was highest at topping and lowest when the leaf was cured, while the reverse was true of lime. Soda was found to be a little lower at topping than at any other time. The percentage of magnesia, sulphuric acid, and chlorin was found slightly increased in the cured state. The plants taken from the plant bed contained, in an air-dried condition, nearly 3 per cent of nitrogen, nearly 1 per cent of phosphoric acid, over 8 per cent of potash, and about 2.5 per cent of lime. Results further show that at the time of topping the whole plant contained about 3 per cent of nitrogen, one-third of 1 per cent of phosphoric acid, about 4 per cent of potash, and over 2 per cent of lime. At the time of cutting it contained nearly 3 per cent of nitrogen, one-third of 1 per cent of phosphoric acid, and more than 3½ per cent of lime.

A series of analyses of different grades of manufacturing tobacco from Virginia, West Virginia, and North Carolina were made by the Virginia Station and reported about the same time as the work described above.[2] The results are of interest in showing to what extent the chemical composition of grades of manufacturing tobacco is subject to variations. The samples analyzed were taken from the crops of 1890 and 1891. The question of varieties was not considered. In the sun-cured tobacco the crop of 1891 in one county contained about one and one-half times as much potash, nearly twice as much sulphuric acid, and one-sixteenth more lime than that of 1890. High-grade bright flue-cured and low-grade bright flue-cured tobacco grown in different counties in different years were found to contain about the same amount of ash, but the low-grade tobacco contained about twice as much nitrogen, phosphoric acid, potash, magnesia, and sulphuric acid as the high grade. The chlorin content of the grades was about the same, but the amount of soda and insoluble matter in the high grade was about six times as much as in the low grade. In one county the potash in the crop of 1891 was about one and one-half times that of 1890, the magnesia and chlorin nearly twice as much, and the insoluble matter about one-fifth as much. The analyses of manufacturing tobacco grown in Virginia agreed very well in their ash content, except in one county, where it was much lower. The potash did not agree

[1] Virginia Station Bul. No. 50. [2] Ibid., No. 51.

except in one or two cases. The lime content varied considerably in all cases and in chlorin and in insoluble matter there was very little agreement. In samples from West Virginia and North Carolina the ash constituents agreed fairly well, but the chlorin varied considerably, varying in the ash from 2.22 to 8.08 per cent. The percentage of ash, nitrogen, and potash was higher and that of lime much lower in the samples from West Virginia than of those from North Carolina.

The Virginia Station[1] shows that in average composition the leaves and stalks do not differ materially except in the nitrogen, of which the leaves contain about two-thirds of 1 per cent more than the stalks. The roots were found to contain on an average nearly 2 per cent of nitrogen, 2 per cent of phosphoric acid, and 1.75 per cent of potash.

The chemical changes in tobacco during fermentation as determined by the Connecticut State Station[2] have been discussed under Effects of Fermentation (p. 28). Complete results of the work are given in the following table:

Analyses of fermented and unfermented leaves.

	Upper leaves.		Short seconds.		First wrappers.	
	Unfermented.	Fermented.	Unfermented.	Fermented.	Unfermented.	Fermented.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	23.50	23.40	27.40	21.10	27.50	24.90
Ash	14.89	15.27	22.85	25.25	15.84	16.22
Nicotine	2.50	1.79	.77	.50	1.26	1.14
Nitric acid (N_2O_5)	1.89	1.97	2.39	2.82	2.59	2.35
Ammonia (NH_3)	.67	.71	.16	.16	.33	.47
Other nitrogenous matters	12.19	13.31	6.69	6.81	11.31	11.62
Fiber	7.90	8.78	7.89	8.95	9.92	10.42
Starch	3.20	3.36	2.62	3.01	2.89	3.08
Other nitrogen-free extract	29.39	27.99	26.28	28.36	25.52	26.88
Ether extract	3.87	3.42	2.95	3.04	2.84	2.92

Analyses of tobacco leaves are reported by several experiment stations as given in the following table:

Analyses of tobacco leaves.

Experiment station.	Moisture.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.	Insoluble matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Virginia[1]	7.62	4.37	0.502	5.738	5.449	0.956	1.943
Massachusetts State, 1891[3]	11.97	2.95	1.150	6.060	4.830	1.360	2.350
Massachusetts State, 1892[4]	13.05	2.75	.430	7.240	4.170	2.170	4.170
Kentucky[5]	6.80	3.02	.960	6.550	.....	.....	.....

[1] Virginia Station Bul. No. 14.
[2] Connecticut State Station Rpt. 1892.
[3] Massachusetts State Station Rpt. 1891.
[4] Ibid., 1892.
[5] Kentucky Station Rpt. 1895.

BURNING QUALITY OF TOBACCO.

A comparison of the fire-holding capacity of a number of different varieties and types of tobacco was made by the North Carolina Station[1] in 1895. Strips of tobacco leaves were pressed out flat, dried, ignited, and the time noted during which they continued to hold fire. Several parts of the same leaf and different leaves from the same lot were tested in this way and the results averaged. The following table shows the results of these tests:

Burning quality of tobacco.

Variety or type.	Where grown.	Glow, in seconds.	
		Average.	Range.
Domestic Havana Eureka	New York	14	5–35
Cigar leaf wrapper	Florida	117	(a)
London Strips	Kentucky	8	5–25
White Burley	do	7	4–18
Wilson Hybrid	Massachusetts	13	5–28
German Spinning Leaf	Tennessee	11	7–15
Pennsylvania Seed Leaf	Pennsylvania	175	(b)
Havana Seed Leaf	Connecticut	16	4–45
Fancy English strips	North Carolina	5	4–6
Bright Wrapping Leaf	Virginia	4	2–8
Austrian Wrapper	do	5	3–8
Italian Regie	do	31	10–90
French Regie Snuff Leaf	do	5	3–8
Fine bright mahogany wrapper	do	6	4–8
Ohio Spanish	Ohio	24	8–50
Small dark wrapper	Virginia	24	14–50
Colory Seconds	Maryland	39	15–65
White Burley	Ohio	4	2–6
Yellow tobacco	Georgia	4	2–8
Do	Alabama	6	4–10
Reddish brown	Kansas	6	4–10
Do	Missi-sippi	6	5–7
White Burley	West Virginia	52	15–150
Seed Leaf	Illinois	12	4–30
Light Brown	Indiana	10	5–25
Spanish type	Tennessee	15	5–40
Bright wrapper (leaf cure)	North Carolina	5	3–7
Bright wrapper (stalk cure)	do	5	4–7
Yellow smoker (leaf cure)	do	8	4–13
Yellow smoker (stalk cure	do	7	4–12
Yellow cutter (leaf cure)	do	8	4–15

a Burned to end of strip. *b* Burned 2½ in. and put out.

A comparison of the chemical composition of the different samples was made, and it was found that the tobacco having the best burning quality contained a high percentage of ash constituents, and that a large percentage of lime and potash in proper combination and an increased percentage of cellulose were associated with good burning qualities. In general, thin leaves with a delicate structure burned better than coarse, heavy leaves. The results further indicate that albuminoids seem to be injurious to the burning quality, while nicotine seems to be an unimportant factor in this connection.

It is generally accepted that tobacco containing a large amount of chlorids has a low fire-holding capacity, and it has been found that an abundance of potash counteracts the effects of chlorin to a certain extent.

[1] North Carolina Station Bul. No. 122.

This seems to have been verified in the sample of Pennsylvania seed leaf from Pennsylvania, which ranked as one of the highest in fire-holding capacity, although containing nearly 1 per cent of chlorin which, however, was accompanied by a high percentage of potash and lime. The sample of French Regie Snuff-leaf from Virginia had a comparatively high percentage of chlorin, but the potash content was relatively small and its burning qualities poor. The author concludes from this observation that the effect of chlorin may be overcome to a certain extent by the amount of potash present, but that very large amounts would probably not be counterbalanced in this way. Of the several ash constituents, potash and lime are considered most important in promoting combustion.

TOBACCO STALKS AND STEMS AS FERTILIZERS.

Since the stalks of tobacco and the stems of the leaves constitute a large part of the crop, which is usually not removed from the farm, the amount of plant food they contain becomes an item of considerable importance. Analyses of tobacco stems when cut and after curing were made by the Connecticut State Station[1] in 1891. From the data obtained the plant food taken from the soil by the stalks while growing and returned to it when plowed under is determined. It was found that the stalks on an acre of tobacco containing 8,000 plants weigh about 9,500 pounds at the time of cutting, and 3,300 pounds when they have been cured. The average results show that these stalks contain 32 pounds of nitrogen, 8 pounds of phosphoric acid, 49 pounds of potash, 3 pounds of soda, 13 pounds of lime, 5 pounds of magnesia, 5 pounds of sulphuric acid, and 6 pounds of chlorin. The amount of nitrogen, phosphoric acid, and potash in the stalks was greater after curing than at the time of cutting.

Analyses of stalks of different varieties of tobacco made by the Virginia Station[2] show that, on an average, the stalks of air-dried plants contained 3.71 per cent of nitrogen, 0.646 per cent of phosphoric acid, 5.02 per cent of potash, and 2.22 per cent of lime. The stalk is considered as constituting a little less than one-fourth of the average plant. The results of using tobacco stems as a fertilizer for tobacco at the Connecticut State Station have been given under fertilizer experiments (p.). Only one other test of this kind is reported. At the Kentucky Station,[3] soil which had received an application of 4,000 pounds of tobacco stems per acre yielded at the rate of 80.1 bushels of ear corn and 6,270 pounds of fodder per acre as compared with a yield of 47.6 bushels of ear corn and 3,940 pounds of fodder on soil which had received no fertilizer. Tobacco stems were the most effective ferti-

[1] Connecticut State Station Report, 1892. [2] Virginia Station Bul. No. 14.
[3] Kentucky Station Bul. No. 17.

lizer in a series of fertilizer experiments with corn. It is stated, however, that it is not known whether the plats on which this test was made had been fertilized alike prior to the time this experiment was undertaken.

Below are given analyses of tobacco refuse as reported by several experiment stations:

Plant food in tobacco refuse.

Experiment stations.	Tobacco stems.						Tobacco dust.		
	Whole.			Ground.					
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Connecticut State *a*	1.04	.56	4.98	2.74	.92	10.08	1.91	.52	1.96
Massachusetts Hatch *b*	.....	.....	.....	2.23	.32	6.10	2.08	.42	2.07
New Jersey *c*	1.70	.68	6.17	1.98	.84	9.76	1.21	.32	1.17
Kentucky *d*	2.77	1.03	9.08	.....	.....	.....	.....	.....	.....
Pennsylvania *e*	1.63	.98	7.60	.....	.....	.....	.....	.....	.....

a Stem analysis, Connecticut State Station Rpt. 1897, p.; dust analysis, Rpt. 1896.
b Massachusetts Hatch Station Bul. No. 48.
c Stem analysis, New Jersey Stations Bul. 84, p.; dust analysis, Rpt. 1894.
d Kentucky Station Rpt. 1895.
e Pennsylvania Station Rpt. 1895.

NICOTINE IN TOBACCO.

The subject of nicotine in tobacco was investigated by the North Carolina and Virginia stations. The Virginia station [1] found that the average percentage of nicotine in the air-dry substance of the leaf of White Burley, Medley Pryor, and Yellow Oronoko was 3.46 per cent when the plants were ready to be topped, 3.79 per cent at the time of cutting, and 5.51 per cent when the leaf was cured. At the time of topping the plants there was little difference in the nicotine content of the leaf of the three varieties, while at harvest time the difference was more marked, the nicotine content in the leaf being 3.21 per cent for White Burley, 4.32 for Medley Pryor, and 3.83 for Yellow Oronoko. In different grades of manufacturing tobacco, the nicotine content ranged from 1.54 per cent in high grade, bright, flue-cured tobacco to 5.56 per cent in English shipping. Among these grades the light tobacco was found to contain the lowest and the dark tobacco the highest percentage of nicotine.

Results obtained at the North Carolina Station [2] indicated that the nicotine, when the plant is mature, is found mainly in the leaves. Analyses of typical tobaccos grown in the United States show that in the samples tested the nicotine in the water free substance of the leaf ranged from 1.45 per cent in Pennsylvania Seed Leaf to 5.53 per cent in German Spinning Leaf, grown in Tennessee. The author associates a coarse, rank growth with a comparatively large amount of nico-

[1] Virginia Station Bul. 52. [2] North Carolina Station Bul. 122.

tine, and states that the percentage of nicotine is materially increased by the use of large quantities of nitrogenous fertilizers. Nicotine was not found to be an important factor in affecting the burning quality of tobacco. It is stated that the nicotine content of tobacco leaf is materially reduced in the process of fermentation, but no figures are given to show to what extent this reduction takes place.

The Connecticut State Station [1] found that the nicotine content was reduced by fermentation from 2.5 to 1.62 per cent in upper leaves, from .77 to .44 per cent in short seconds, and from 1.25 to 1.05 per cent in first-wrapper leaves.

ARSENIC IN SPRAYED TOBACCO.

The presence of arsenic in tobacco sprayed with arsenites was studied by the Kentucky Station to determine whether or not enough arsenic was left on the leaves of the plant to injuriously affect the health of the consumer.

In 1894 [2] tobacco was sprayed with Paris green and London purple solution. It is estimated that individual plants sprayed once with Paris green received 1.0329 grains of arsenic, those sprayed twice, 2.00456 grains, and plants sprayed with London purple, 1.8957 grains. The chemical examination of the sprayed tobacco showed that whether the original amount of arsenate was large or small only a comparatively small portion remained on the plant at the time of harvesting. The largest amount of arsenic obtained in these investigations was 0.329 grain per pound of tobacco, or only about 4 per cent of the arsenic originally applied. The plants sprayed but once retained about 1.8 per cent of the amount left by spraying, and those sprayed with London purple about 3.2 per cent.

In 1895 [3] the inquiry into this subject was continued in connection with another experiment. Plants were sprayed 1 to 8 times, from July 3 to August 22, with a solution of one-fourth pound of Paris green to 40 gallons of water, and the amounts of arsenic which they retained at cutting time were determined. The amount of Paris green applied varied with the number of applications, ranging from 0.1 to 0.8739 ounce per row. Plants sprayed once or twice showed only a trace of arsenic, and since some arsenic was found in tobacco which had not been sprayed it is concluded that practically all the arsenic left by spraying was gone when the plants were cut on September 4. A number of plants which had been sprayed only once, but were sprayed again on September 5 and cut as soon as they were dry, contained 0.0139 per cent of arsenic, evidently obtained from the last spraying. The tobacco which was sprayed 8 times contained 0.0093 per cent of

[1] Connecticut State Station Report 1892. [2] Kentucky Station Bul. No. 53.
[3] Ibid. No. 63.

arsenious oxid. These results are considered as showing the extent to which arsenic is removed when the plants are not harvested until some time has elapsed after spraying. It is further pointed out that applications of Paris green shortly before harvesting should be avoided.

"While the question * * * is still open to discussion * * * it may be confidently asserted that the amount of arsenic contained in the small fraction of a pound which a man would consume in a day, even if taken at one dose instead of being distributed throughout twelve hours, would produce no harmful effect."

INSECTS AFFECTING TOBACCO.

Most of the common insect pests which are troublesome to tobacco culture have been studied by the stations. The Kentucky Station has given attention to the prevention of depredations by the tobacco worm, the bud worm, the flea beetle, the spined tobacco bug, and grasshoppers. The spined tobacco bug,[1] which causes the plants to wilt suddenly and thus checks their growth, was noticed to attack tobacco plants grown next to a pasture, whence the bugs are believed to have come. As a remedy, removing the bugs from the wilted plants is suggested, and as a preventive measure, not to allow weeds, especially thistles and mullein, which are very attractive to these insects, to grow near tobacco fields is recommended.

It was also observed that when corn becomes inedible to the corn worm this insect attacks tobacco grown in adjoining fields. To obviate this trouble it is advised not to grow early corn near tobacco.

It was further noticed that grasshoppers[2] sometimes do damage to tobacco when grass or other close-growing crops upon which they have fed are removed. The use of Paris green was found to destroy them, but not before some damage had been done. The author suggests that all unnecessary growth likely to harbor these pests near the fields should be kept down.

Several specimens of bud worms were studied.[3] They left the tobacco plants and went into the ground August 10, and the adult moths came out about two weeks later. It was observed that the specimens under observation gnawed holes in the young leaves at the center of the plant before they were unfolded. A thorough application of Paris green is considered a suitable remedy.

For the flea beetle, dusting with pyrethrum or spraying with a solution of this powder is regarded as preferable to the use of lime water, which deteriorates the quality of the leaves by the deposition of lime.

For the prevention of damage by the tobacco worm,[4] the ordinary practice of putting sirup poisoned with cobalt, arsenic, or strychnine

[1] Kentucky Station Bul. No. 66. [2] Ibid. No. 63. [3] Ibid. No. 49. [4] Ibid. No. 40.

into the blossoms of jimpson weeds to poison the moths is worthy of recommendation. It is advised that the late brood of worms which feeds almost exclusively on tomato plants be destroyed by the use of poisons or kerosene emulsion.

Young tobacco worms[1] were observed on tobacco plants early in July, August, and September. Of these different broods the one appearing in early August is regarded as the most injurious, but the brood appearing in July is not without its bad effects. The station concludes from its experience that the best remedial measure is to spray with a solution of 1 pound of Paris green in 120 to 160 gallons of water, making the application as soon as the young worms appear. The author states that spraying more than three times is unnecessary when the times of making the application are well chosen.

In 1896[2] the tobacco worm was very abundant, and further observations were made by the station entomologist. The average persistence after treatment of the young worms was 4.43 days and of the large worms 12.33 days. The average duration of all lots of worms treated with a solution of 1 pound of Paris green in 40 gallons of water was four days, and when a mixture of 1 pound of Paris green in 150 gallons of water was used, 14.17 days. The weaker solutions were found sufficiently strong for the destruction of the young worms, but in destroying the large worms the strong solution proved the most effective.

The Maryland Station[3] found that a poisoned mash, consisting of 50 pounds of wheat bran, 2 quarts of molasses, 1 pound of paris green and water, dropped from three to five days before planting, near the places where the plants are to be set, prevented the cutworms from injuring tobacco fields.

In testing tobacco seed the Florida Station found that apparent damping-off of the seedlings was due to nematode attacks.[4] The seedlings were grown in sand which had been kept air dry for ten months prior to sowing the seed. The injury was produced by the worms from the outside at any point on the plant. When attacked the points of irritation became enlarged, the development of the seedling was arrested, and the final result was the destruction of the young plant. To prevent the trouble, the author advised growing tobacco seed on uninfested soils, and states that old land is apt to be infested, and that this may be ascertained only by observation of the trouble in previously grown crops.

TOBACCO AS AN INSECTICIDE.

As an insecticide tobacco has a wide application and its use for this purpose, it is safe to say, has been tested by every experiment station

[1] Kentucky Station Bul. No. 63.
[2] Ibid. No. 66.
[3] Maryland Station Bul. No. 55.
[4] Florida Station Bul. No. 24.

in the country. A brief summary of the methods of application and the results obtained at a number of stations are here given.

Tobacco decoction was used with effect by the New Jersey Experiment Station[1] against attacks of flea beetles on potatoes, plant lice on rose bushes and chrysanthemums, the wheat louse, the larvæ of the rose tortricid, and the rose slug, but its effects were not satisfactory when used for the larvæ of the elm leaf-beetle, hairy caterpillar, rose chafer, and striped beetle. Coarsely ground tobacco dust was ineffective when applied on dry plants but had some effect on moist plants. Finely ground tobacco dust was much more effective. The addition of carbolic acid to tobacco powders increased their efficiency fully 50 per cent. The author states that tobacco dust put into the soil was successfully used in 1890 by Dr. E. F. Smith as a remedy for the peach louse; either tobacco decoction or tobacco dust was ineffectual as a remedy for the rose chafer.[2] It was found that the horn fly[3] succumbed very readily when brought into contact with tobacco powder.

The Ohio Station found that dusting lettuce, roses, and other plants grown in greenhouses with tobacco powder destroyed the plant lice[4] with which they were infested.

At the Michigan Station[5] tobacco decoction was successfully used to free currants, gooseberries, and apple trees from plant lice and cherry, plum, and pear trees from slugs. It also proved effective against striped flea beetles and cucumber flea beetles.[6]

Experiments conducted at the Missouri Experiment Station showed that applications of tobacco dust were effective in preventing depredations by the woolly aphis of the apple or apple-root plant louse.[7]

TOBACCO SOILS.

A comparative study of tobacco soils is reported by the Pennsylvania Station. The investigations were made in 1894 on Pennsylvania soils from Donegal and Lititz, in Lancaster County, and Rocky Spring, Franklin County; and also on soils from the best wrapper-leaf districts of New England and North Carolina. The best tobacco soil from Granville County, N. C., the soil of the "plains" land at East Hartford, Conn., and the soil from Poquonock, Conn., were composed chiefly of medium fine and very fine sand. Tobacco soil from Granville County, N. C., and the soil from Podunk, Conn., Hatfield, Mass., and Rocky Spring, Pa., consisted mainly of very fine sand and silt, the Rocky Spring soil being very largely composed of silt and the others of fine sand; and the tobacco soils from Donegal and Lititz

[1] New Jersey Station Bul. No. 75.
[2] Ibid. No. 82.
[3] New Jersey Station Rpt., 1889.
[4] Ohio Station Bul. No. 2, vol. 4.
[5] Michigan Station Bul. No. 118.
[6] Michigan Station Bul. No. 58 and Rept., 1890.
[7] Missouri Station Bul. No. 35.

were composed mainly of very fine silt and clay. The mean soil temperature during the growing season at Rocky Spring was 76.1°, and at East Hartford and Poquonock, 77.4°; but at Rocky Spring the difference between day and night temperatures was smaller than at the other places.

The moisture content of tobacco soils from a number of localities, including those already mentioned, was determined and its variation during the season observed. The average percentage of moisture determined in the various soils was as follows: Soils from South Deerfield and Hatfield, Mass., 19.5 to 22 per cent; from East Hartford, Conn., South Granby, N. Y., and Rocky Spring and Donegal, Pa., 14.5 to 17 per cent; from Bloomfield and Windsor, Conn., and Saxon and Cana, N. C., 9.5 to 11.5 per cent; and soil from Poquonock, Conn., 7.5 per cent. The range of variation of moisture content during the season in Rocky Spring soil was 11 per cent; in soils from Donegal, South Deerfield, South Granby, Cana, and Bloomfield, 3.5 to 5.5 per cent; in Hatfield, Mass., and East Hartford and Windsor, Conn., soils, 2 to 3 per cent; and in soils from Poquonock, Conn., and Saxon, N. C., 0.5 to 1 per cent. It is concluded that the Rocky Spring soil is most subject to the influence of short droughts. The water-holding capacity of the dry subsoil from Donegal was 52 per cent, and of that from Rocky Spring 45 per cent. The soil at Donegal was found capable of absorbing 3.25 per cent of moisture from the atmosphere, and the soil at Rocky Spring 3.09 per cent. In general the soils from Lancaster County, Pa., were found to be heavier and somewhat more moist than the best wrapper-leaf soils of other districts, and, so far as examined, warmer and more equable in temperature. The investigations further pointed out that these soils rank well in fertility and did not contain injurious constituents in excessive proportion.

Tobacco was grown on different kinds of soils by the Louisiana Experiment Station.[1] It is concluded from the results obtained on old worn lands and pine thickets in northern Louisiana that such soil is well adapted to the culture of the yellow or bright leaf varieties of tobacco.

In 1894 White Burley tobacco grown on the red heavier sandy soil of northern Louisiana gave as good or even better results than when grown on the lighter soils, and Oronoco, a bright variety, cured as brightly when grown on the one soil as when grown on the other. Cigar leaf varieties also grew better on this type of soil than on the lighter sandy soils.[2] It was found that the lighter the land the more readily tobacco cured brightly.

The North Carolina Station found that the light sandy soil of Granville County of that State produced a tobacco with a large percentage

[1] Louisiana Stations Bul. 20. [2] Ibid. 33.

of carbohydrates, especially starch and glucose. The soil of this region contains a very small percentage of available mineral matter and seems to be especially adapted to the production of yellow tobacco.

Below are given some of the results of soil analyses made by different stations in connection with their investigations on tobacco:

Results of tobacco soil analyses.

	Soils from—				
	Colorado. *a*	Virginia. *b*	North Carolina. *c*	Florida. *d*	Cuba. *e*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	2.78	0.577	0.312	1.000	14.200
Organic matter	4.53	2.982	*f* 1.510	.950	12.300
Insoluble matter	72.71	.....	95.642	97.000	32.300
Phosphoric acid	.21	.019	.016	.053	1.600
Potash	.41	.019	.161	.018	.160
Nitrogen	.02	.090	.....	.028	.320
Lime	.70	.076	.240	.130	7.600
Magnesia	.85	.036	.047	.008	.170
Iron oxid	3.37	1.550	.326	.790	29.400
Alumina	4.29		1.038	.....	.....
Soda	.71	.038	.109	.030	.084

a Colorado Station Bul. No. 10.
b Virginia Station Bul. No. 12.
c North Carolina Station Bul. No. 90a.
d Florida Station Bul. No. 19.
e Florida Station Bul. No. 19.
f Reported as volatile matter.

The Division of Soils has made quite an extensive study of the principal tobacco soils of the United States and has issued several bulletins thereon.[1] It will be unnecessary to summarize the results here as the publications can readily be obtained.

CONCLUSIONS.

Having thus reviewed the work of the experiment stations, it will be well to outline clearly the general purpose of tobacco investigations in order to understand fully the most important lines to be developed.

One of the questions most frequently asked is the possibility of extending the culture of tobacco to new areas. While tobacco is confined as at present to comparatively small areas, and while it continues to be one of the "money crops" of the farm, there will naturally be a widespread desire to extend the cultivation to new localities. This is one of the most difficult things to advise about, as so little is known about the influence of climate and other conditions upon the quality of the leaf.

The tobacco industry is so highly specialized that a nondescript tobacco is no longer needed and brings only a very low price. The qualities of the tobacco leaf, including the size, shape, and thickness of the leaf, the flavor and aroma, the grain and general style, are so delicate, so easily influenced, and as yet so difficult to control that it is impossible to say beforehand what qualities a leaf would have raised

[1] Bul. No. 5, Texture of Some Important Soil Formations. Bul. No. 11, Tobacco Soils of the United States. Farmers' Bul. No. 83, Tobacco Soils.

under new and untried conditions. Such work must, therefore, continue to be largely a matter of trial and blind experimentation. Some characteristics can be foretold, of course, from the general conditions and the character of other crops. Much will depend, of course, upon the judgment and knowledge of the producer. Then, again, it is difficult or impossible in most cases, even after the tobacco is grown, to judge of the quality until after the long and careful treatment required in the curing and fermentation of the leaf to develop and fix the style of the leaf and to develop the aroma. Furthermore, this manipulation can be done successfully only with a large quantity—at least 2,000 pounds—and after the most improved methods.

A majority of the experiment stations are not favorably located for any very valuable economic work along the lines of tobacco investigations. Such work can best be done by stations located in the tobacco areas. It would seem desirable, therefore, that two or three of the stations which are suitably located in different tobacco areas should take up the subject in a comprehensive and thorough manner. It would be well to have at least one station in the manufacturing and export districts and one in the cigar-tobacco districts devoting their main energies to this one subject in the same manner as other stations are specializing in sugar production, stock feeding, dairying, and other lines.

The main purpose of this work should be the improvement of the leaf to adapt it better to the present market demands. It will therefore be well to look into the requirements of the market, see where our tobaccos can be improved, and then decide upon the lines of investigation.

Tobacco is divided commercially into four classes: (1) Domestic cigar; (2) cigarette; (3) domestic manufacturing (chewing, smoking, and snuff); (4) export.

The domestic cigar is made up of wrapper, binder, and filler. The most important of these from a commercial standpoint is the wrapper. A leaf to be used as a wrapper to suit the present market demands must have quality and style, that is, it must appear well when wrapped on the cigar, it must be uniform in color, free from holes or tears, it must be very elastic, so that it can be wrapped smoothly and tightly on the cigar, it must have the proper color, it should be of a certain size and shape to avoid waste, and it should be as free as possible from all aroma or flavor which could in any way mask the desirable qualities of the filler. Although the thin wrapper used at the present time constitutes only about one-fifteenth or one-twentieth part of the weight of the cigar, it may have a very marked influence upon the cigar, very much more influence, apparently, on account of being wrapped on the outside than if the same leaf were put inside as part of the filler. The reason for this is not clearly apparent, but is probably connected with

the combustion products and the access of air. Certain it is that the flavor and aroma of the wrapper is always fully considered in blending tobaccos for the high-priced cigars.

The filler tobacco, on the other hand, must have a rich aroma and a desirable flavor. The best Cuban tobacco has a characteristic aromatic flavor which it has been impossible to obtain in any section of this country, but which there is every reason to believe can be developed by selection and breeding in certain districts in this country.

Mr. Floyd has brought out so clearly the requirements of the cigar-leaf trade and has shown the steps taken and the great success obtained by the Florida growers in meeting these requirements that a short abstract from Report No. 62 of this Department is here given:

All are fairly well agreed that for wrapper purposes the Sumatra furnishes the ideal leaf, while for fillers, where quality is needed, the island of Cuba produces the best leaf. As these tobaccos are the standard of quality and style sought after, it should be the aim of each tobacco-growing section to produce as nearly as possible a tobacco that will take the place of these imported goods, both in appearance and quality. The first essential in all cases is that the tobacco, whether wrapper or filler, burn smoothly and freely. Next, there must be quality, the taste must be pleasant, not rank and strong, nor too mild. The wrapper must have style. That means that a wrapper, to be acceptable to the manufacturer of the high-grade cigars, must be light in color, rich in grain, thin in texture, small in vein and stem, very elastic, and of good burning quality. The most desirable sizes are 16 and 18 inch leaves, as from leaves of these sizes the manufacturer will get four wrappers from each leaf and have very little waste, which is always quite an important item to consider.

The first essential is that the wrapper leaf be grown; the next that it be properly cured, assorted, and classified. A manufacturer will never pay a high price for a bale of tobacco unless he can calculate just what it will yield him, and this he can only do when it is well and carefully selected. The tobacco should be uniform in size, color, and texture, as when a bale of tobacco contains a variety of colors, sizes, and textures the buyer is left to guess its value and the price will necessarily be low.

For filler purposes Cuban tobacco makes the standard. The size of the leaf should be from 12 to 14 inches, not longer, and it should not be very dark and heavy, as many seem to think, but of medium body, and of a rich brown color, burning smoothly and freely. All manufacturers agree that it is never well to make a cigar from only one kind of tobacco—that is, a cigar should not be made in which the entire filler is Ohio, Pennsylvania, or Florida tobacco, but tobacco should be taken from these various sections and a combination tried until tobaccos are found that blend well. When this result is secured, the combination is adopted, and a new brand of cigar is put on the market. This is especially true of the Cuban tobacco. Many of the manufacturers would gladly reduce the amount of imported Cuban tobacco if they could be supplied with a domestic tobacco that would blend well with it.

For the past ten years Florida has done much to show what could and should be done. Finding that the trade could not be forced into taking whatever might be produced, it was determined to grow as nearly as possible a tobacco similar both in appearance and quality to that grown on the islands of Sumatra and Cuba. To do this the best seed obtainable was secured from these islands, and, as far as practicable, their methods of cultivation, harvesting, fermenting, and manipulation were employed. How well these efforts have succeeded may be judged from the fact that Florida fillers, when well cured and baled, bring to-day as high as 45 cents per

pound, while wrappers bring from 50 cents to $2 per pound, according to style and quality.

This applies to the Cuban variety. So far as the production of the Sumatra type of tobacco in Florida is concerned, there is equal assurance of success. Unquestionably bales of that type of tobacco have been grown and packed so that the best experts could not distinguish from the imported goods, and some of this, grown under shade, has been sold for $4 per pound. Of course, these bales contain tobacco that has been selected with great care, each leaf being perfect. Two pounds of such tobacco would wrap 1,000 cigars, all "first," and equal to those wrapped with imported goods. This shows that when we offer to the trade the proper goods it is willing to pay for them. We have much yet to learn, as the percentage of this finer grade of wrapper has been very small compared with the quantity grown, thus causing the selection and classification to be very expensive, as it requires the assorting of a large quantity in order to obtain a very small percentage of desirable wrapper leaf. However, as before stated, we have met with sufficient success to warrant the belief that in the near future we will produce a leaf that will take the place of the imported Sumatra.

In order to improve the tobacco and adapt it to the trade demands there were many questions to be settled. First of all, what seed should be used. To settle this question seed was obtained and tried from every part of the country. This point, however, was soon determined, and now there are only two varieties grown in the State—Sumatra and Cuban—the Sumatra giving the style required for the wrapper and the Cuban giving the filler qualities nearest the requirements of the trade. As each of these tobaccos possess the quality and style needed, the kind of soil best suited to each was the next point to be settled; then the proper fertilizer, the quantity necessary, and the proper cultivation had to be found out by numerous experiments. At first it was thought that but little fertilizer of any kind should be used. The tobacco was set out early, given a distance in the drill of about 24 inches, and topped low; that is, not more than 12 or 14 leaves were allowed to each stalk. The result was that the plants produced large, coarse, undesirable leaves. The next step was to give the tobacco less distance in the drill; 18 inches were tried. The result was better, but not satisfactory. From time to time changes were made until now the plant is given 14 inches, the fertilizer is doubled, and the tobacco is topped higher, allowing at least 16 leaves to each stalk. The result is that the leaves are of the desirable size and finer in quality and appearance.

For a long time the cultivation was continued until the time of harvesting, but this was decidedly wrong. The writer has seen fields of tobacco plowed that were ripe and ready to be harvested, and in consequence the tobacco turned green and started a new growth. This generally increases the yield, but almost totally destroys the quality of the tobacco. At present the cultivation stops as soon as the plants are topped.

When the Sumatra seed was first introduced into Florida, the land selected, the amount of fertilizers used, and the methods of cultivation and harvesting employed were the same as those practiced in growing the Cuban variety. With this treatment Sumatra proved to be an absolute failure; many abandoned the seed, while others continued to experiment. It was soon found that the soil had to be exceedingly rich, the growth quick; that low topping was ruinous; and that each stalk should have from 24 to 30 leaves, according to the strength of the soil. When the land was exceedingly rich it was found best not to top at all, but to allow the plants to go to bloom. Then the leaves would be of desirable size, thin and smooth; whereas if topped the leaves would curl and thicken. This tobacco is also crowded into the drill, the plants being given only from 12 to 14 inches. The growth is rapid; the top leaves soon serve as a shade for the middle and lower leaves, and the results have

been most gratifying. New land proved to be more desirable for this variety of tobacco, and it was noticed that when trees were left standing in the field the plants shaded by trees were far superior to the plants not so shaded. From this idea of building artificial shade had its birth. It was also found that the plants should not be cut in the usual way, but the leaves primed off just as they ripen, and at a very early stage of ripeness.

These experiments, while conducted by practical men for their own commercial advantage, have been truly scientific and may well serve as an example for scientific work along economic lines under our experiment stations.

Just such work as has been done in Florida in the development from the "Old Florida" leaf to the present style of Sumatra wrapper needs to be done in the improvement of the wrapper leaf of the Connecticut Valley. In the first place the Connecticut leaf is too large to be economically used for wrapping cigars. The tip of the leaf has a good grain and good style, but only one wrapper can be obtained from each side of the leaf near the tip which is suitable to go on a good cigar. The remainder of the leaf can be used only on medium and low-priced cigars, and not even on them when the veins are too large and the surface smooth and glossy and without grain or style. Both the Havana Seed and Broad-leaf have too much taste and aroma. These qualities are so strong that they may altogether mask the desirable qualities of the filler leaf. With some tobaccos they blend very well, but on the whole it is not desirable to have a wrapper of this kind. The Havana Seed-leaf in particular has a peculiar "seedy" flavor which is very characteristic and not at all agreeable to many smokers. The leaf is large, averaging about 26 inches in length. The veins are large, while the lower part of the leaf is so glossy that there is much waste which can not be used in any way in this country.

There is no question but that the proper line of experimentation in regard to this tobacco is to depart radically from the present type and, as Mr. Floyd says, try to produce as nearly as possible in all essential particulars the Sumatra type of wrapper leaf. Much may be done by following the steps taken by the Florida growers in changing the methods of planting, cultivating, and fermentation, but much will yet remain, probably, to be worked out by the plant physiologist in the selection and breeding for certain qualities.

The Pennsylvania filler brings from 4 to 8 cents per pound; the Cuban-grown filler pays a duty of 35 cents per pound and sells for from $1 to $1.50 per pound. It would seem that the proper steps to take here are clearly shown. The matter of the yield per acre is relatively unimportant, the effect of fertilizers is comparatively small, while the crop sells for so little. The great object to be attained is to make a radical departure from the present type and try to approach more nearly the Cuban type of filler with the rich, aromatic aroma

and desirable flavor that is characteristic of the better grades of Cuban tobacco. This work also will involve radical departures from the present methods of cultivation and of fermentation, but even with the best that can be done in this line it is probable that much will yet remain to be done by the plant physiologist in the improvement, by selection and breeding, of the aroma.

So far as present experience goes, it would appear that the investigations in Connecticut should be with the idea of producing desirable wrapper leaf; in Pennsylvania and Ohio the conditions seem to be peculiarly adapted to the production of a desirable filler; in Florida, wrapper leaf alone should be considered, while so far the tobacco districts of Texas have given evidence that the conditions are best adapted to the production of a rich filler leaf.

The problems connected with the cigar tobacco industry are very marked and sharply defined in the preceding paragraphs. The cigar tobaccos of this country do not come up to the present requirements of the cigar trade. We have very satisfactory standards in the Sumatra tobacco for the cigar wrappers and in the Cuban tobacco for cigar fillers.

In the matter of the manufacturing and export types, the lines of investigation are not so clear nor so well defined. The cigarette tobacco of Virginia, North and South Carolina, and East Tennessee are admirably adapted to their purpose. They are themselves the standard for this particular class of leaf. They are not only adapted to domestic use for cigarettes and plug wrappers, but they are exported in increasing quantities to many foreign countries. The average price of the bright yellow and the mahogany leaves are lower than they were a few years ago. The fine, bright wrapper leaf sells for from 25 to 40 cents per pound and the mahogany wrappers for 25 cents per pound. Fancy leaves still sell for from 60 cents to $1 per pound. A specimen of 10 pounds of fancy, bright tobacco was recently purchased by a gentleman in the warehouse at Raleigh, for which he paid $1 per pound, the tobacco to be used for the tobacco exhibit of the Paris Exposition. This tobacco was really a very fine specimen, and the price paid was unquestionably the true commercial value of the leaf. The low price of the inferior grades is due to the fact that there is so much really inferior bright and mahogany tobacco placed upon the market. The effort on the part of the experiment stations should be to investigate the cause of this and to raise the standard of quality of the average crop. The very marked improvement in the manipulation and production of this cigarette tobacco in recent years leaves no reason to doubt but that results can be obtained in generally improved methods for the improvement of the average crop of bright and mahogany tobaccos grown in this country.

Burley leaf and the various export tobaccos seem well adapted to the purpose for which they are now used. There is no need of a radical change, as in the case of the cigar tobaccos, but there is need of a general improvement of the average crop. In the Burley tobacco, for example, the lugs and two grades of tobacco inferior to this form a large proportion of the crop, and bring low prices. The object should be to obtain more of the better grades of leaf from the stalk. The same thing is true in regard to the export tobaccos. The French C sells for about 3 or 4 cents per pound. This appears to be satisfactory to the French Government for a certain class of consumers. It should not be satisfactory to our farmers to produce such a low grade of leaf.

The Austrian A brings from 15 to 16 cents per pound, while Great Britain and Australia take tobaccos which bring from 20 to 30 cents per pound.

To a certain extent the grading is done by the growers—that is, if the leaf gives promise of being adapted to the English market it is harvested green or underripe and is heavily smoked, as these are requisites of the English market for certain classes of tobacco. If it is inclined to be light and trashy it is gathered overripe for the French trade. As a rule, however, the tobacco is graded by the packers and dealers, who sort it out in strict accordance with the character and quality of the leaf. If they assign a sample to the French C it is because it is of poor quality and is not adapted to the Australian or English markets. As a general rule the high-priced tobaccos are manufactured in this country for domestic use, and the lower-priced goods are sent abroad. Still, however, more and more of our high-priced tobaccos are being sent abroad.

In addition to these broad and important economic lines of investigation, there are many problems connected with the chemical composition of the leaf, the chemical substances produced in the leaf, the relation of nicotine to the flavor and aroma, the changes in the curing and fermentation, the influence of soil, of seed, of climatic conditions, of cultivation and of handling, which are of great importance as aids in changing the style or character of the leaf to conform to the market demands.

The chief features of the cigar wrapper are the style of the leaf, the size, uniformity of color, and the absence of any pronounced flavor or aroma. The chief features of a filler leaf for cigars are flavor and aroma. In the fine, bright and mahogany tobaccos it is mainly the color which determines the price. In the manufacturing and export types the quality, size, and shape of the leaf and color determine the market and the use to which they are suited.

These are broad economic lines suggested for investigations, which it is very desirable that some of the stations should take up. The

question of the proper method of preparing the seed bed, the question of the effect of fertilizers, the burn, etc., should all be subordinated to the one great problem of presenting the leaf required by the cigar manufacturers. These questions will naturally be considered in working out the broad problems, but they should not be given the first place and be considered complete in themselves.

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